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HANDBOOK
FOR
DIRECT IMAGE VIEWER

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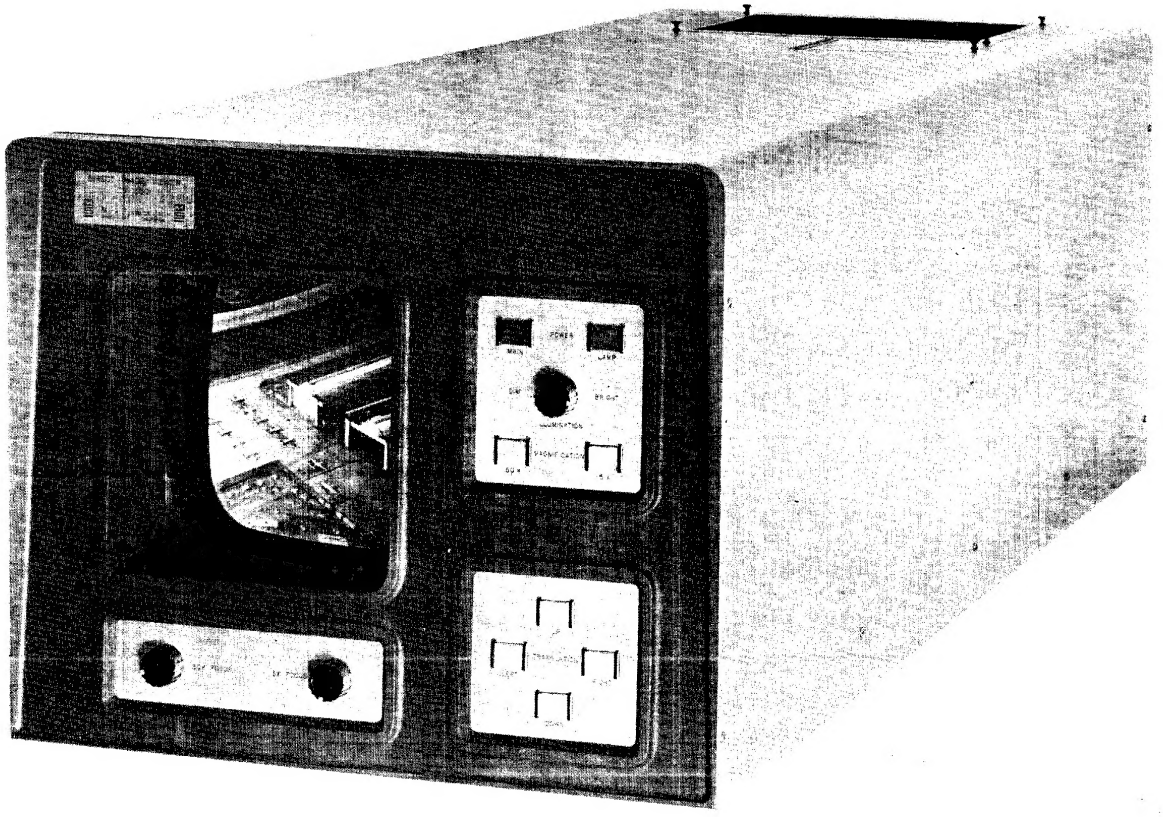

DUAL MACNIFICATION, DIRECT IMAGE VIEWER

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Figure 1

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LIST OF ILLUSTRATIONS

I. PERFORMANCE CHARACTERISTICS AND DESCRIPTION

A. Performance Characteristics

The Direct Image Diffraction Viewer (Figure 1) employs a unique approach to high resolution rear projection viewing of photographic films. Diffraction gratings and a large field lens are used to provide an observer with an enlarged aerial image which can be viewed simultaneously with both eyes.

The various characteristics of this viewer are listed below.

1) Magnification - dual magnifications of 5X and 50X.

2) Observable Film Area - the observable film area consists of a two (2) inch by two (2) inch square area in the film plane at 5X magnification, and two-tenths inch by two-tenths inch square area in the film plane at 50X magnification.

3) Film Size - the viewer accepts for viewing single frames of either 4 x 5 inch or 70mm x 100mm film chips.

4) Exit Pupil Size - the size of the composite exit pupil is at least 3.5 inches square.

5) System Resolution - at 5X magnification, the viewer is capable of providing a system AWAR resolution of 20 lines per millimeter over the used field when referred to a low contrast target in the object plane. At 50X magnification, the viewer is capable of providing an on-axis resolution of 200 lines per millimeter at the film plane with a low contrast target.

6) Light Intensity - the illumination system is variable and presents to the eye, with an open film gate, that amount of light flux as presented to the eye by a lambertian source with illuminance of 100 ft-lamberts.

7) Illumination Spectrum - the illumination of the viewer system is contained in a narrow portion of the spectrum centered around 508.6 millimicrons. Various filters may be used to provide different band passes.

8) Film Positioning - the viewer incorporates a provision for remote film positioning through X and Y translations to permit full coverage viewing areas for either 70mm and 5 inch film chips.

9) Focusing - manual fine focusing control is provided for each magnification.

10) Film Temperature - the temperature of film when mounted in the film plane of the viewer during operation does not exceed 90^{o}F with an average density (silver) of 0.8.

11) Viewer Controls - the control panel contains the following:

a) main power - ON/OFF
b) lamp ON/OFF
c) illumination intensity control
d) magnification selector - 5X and 50X
e) lens focus - 5X and 50X
f) film translation $\pm$2 inch X
$\pm$2 inch Y

12) Physical Size - the viewer has the following general dimensions:

length - 81 inches
height - 23 inches
width - 29 inches

B. Description

1. General Theory of Operation

In direct viewing optical instruments, such as a microscope, the exit pupil is small, requiring that the operator place his eye close to the eye piece for satisfactory viewing. The present Experimental Direct Image Viewer, with its large optical elements and diffraction grating, enlarges the exit pupil in a manner that the operator may view with both eyes the image and still have adequate head movement. In the absence of employing diffraction gratings in the present viewer, a single small exit pupil would exist, which would restrict the operator to the use of a single eye and no head movement when viewing at high magnifications. Through the insertion of the gratings in the optical path, and the use of a narrow portion of the spectrum, many exit pupils are created, which when arranged side by side and placed both above and below one another, form a matrix of exit pupils in space providing an effective viewing area of 3.5 inches square, where the operator may place his eyes for viewing. This unique approach results from the use of a special field lens, and specially designed and built set of diffraction gratings. Narrow band spectrum must be used in the viewer, or the diffraction characteristics of the gratings will produce various colored matrix exit pupils.

2. Description of Machine

a. X-Y Translation Mechanism

Both the 4 x 5 and 70mm film areas are held flat by two interchangeable platens, each with a vacuum manifold which operates over the entire film area. This form of film hold down provides an accurate flat film plane with no air entrapment. The interchangeable film platens are removed from the machine for easy loading and can be re-inserted in the Y slide shown in Figure 5. The Y slide is then driven over a total distance

of four inches (±2 inches) by a ball screw and nut. The yoke, which supports the Y slide and Y drive motor, slides on the large ball bushings and rails for the X movement and translates for the required magnification change.

A long ball screw and nut is used to perform this operation. This dual function is provided by the drive package shown in Figure 10. The smaller gear motor drives the yoke back and forth in X for the required ±2 inches. When a change in magnification is made, the duplex clutch connects the higher speed motor to the ball screw and translates the yoke 9 inches from one optical axis to the other, so that the same area of film is being viewed at either magnification. This movement is accomplished by the gear reduction and cam actuated microswitches. The gear reduction is chosen to insure that the travel of the cam from one microswitch to the other provides the 9 inch travel between magnifications.

The yoke is supported both above and below the film chip to insure the film is maintained in the image plane of the lenses. This operation is critical since the 50X lens has a very small depth of focus when operating at F/1 and above a resolution level of 200 l/mm. Although the viewer has the ability to permit viewer focusing of the lenses at the different magnifications, the rigid platen mechanism eliminates the necessity for performing frequent viewer focusing operations.

b. Light Source and Condensers

Two 1500 watt lamps are used to provide the required illumination, Figure 7. For this experimental viewer a continuous spectrum source was selected so that various wavelengths could be tested. These 1500 watt projection lamps are mounted in a housing through which air at a velocity of approximately 1500 ft/min. is passed. This air is provided by

two vane axial blowers, see Figures 8 and 9. The air is ducted through the rear of the machine. A heat transmitting reflector is mounted on the rear side of the ducting. A tube connects the front of the ducting to the condenser elements, see Figure 5. The front element has a reflective coating for IR radiation. These condensers contain heat reflecting mirrors to remove any heat that passed through the first condenser lens. The light then passes through the colored interference filters and the remaining condenser lenses.

c. Objective Lens Assembly

Two commercial lenses are used to provide the 50X and 5X images. These lenses are modified to contain square apertures with apparent side dimensions of .707 inches. This dimension is adjustable ($\pm$10%) by the use of the standard focusing ring.

The 50X lens has a 1 inch focal length and is used at an aperture equivalent to f/1. The 5X lens has a 210mm focal length and is used with an aperture of approximately f/8. Each lens is mounted on an "h" shaped mount which is spring loaded against a tapered shaft driven by a cam through a worm gear from the focus knob. This arrangement places all the mechanisms under the mounting table and provides a fine, smooth operation. One full turn of the 50X focus knob will move the lens 0.002 inches. With the greater depth of focus of the 5X lens, this is adjusted to provide 0.006 inches per knob revolution. A total travel of 1/8 inch is provided for each lens. This mechanism is shown in Figures 6 and 10.

Two mirrors are used to deflect the optical path from 50X to 5X, shown in Figures 5 and 6. The movable mirror is mounted on a slide which is driven by a motor and crankshaft. The gear head output of the motor operates in 180^{o} intervals, controlled by a microswitch and cam, to slide the mirror to the forward (5X) or rear position out of the 50X optical path.

A field flattener is used in each optical path to compensate for the slight curvature introduced to the image plane by the field lens preceding the diffraction grating.

d. Field Lens and Grating

A 16" diameter field lens is used to image the square aperture of the objective lenses in front of the viewer as an exit pupil.

The field lens is made up of two parts with the grating mounted between them. The light bundle falling on the grating must be parallel from any point on the objective. This requires that the focal point of the first element fall at the exit pupil of the objective lens. The parallel bundles go through the grating and are imaged at the next two elements focal point which is 20 inches. The first element preceding the grating is operating at f/3, whereas the outer two elements provide an f/1.3 cone.

The grating between the lenses is operating on the Fraunhofer diffraction principle. A two dimensional array of exit pupils is created by the grating. The diffraction must occur with reasonably uniform transmission over ± 13 orders to provide the 3.5 inch exit pupil matrix.

The field lens with grating installed is shown in Figure 3.

II. OPERATION

A. Preparation for Operation

The viewer should be placed in a room with variable intensity illumination. For best operator comfort the luminance of the surroundings should be less than 5 foot-lamberts.

The rear panel of the viewer should be at least 12 inches from any vertical partition or wall to provide adequate air flow for cooling of the projection lamps.

The electrical circuit for the viewer should be fused for a minimum of twenty amps.

The vacuum pump can be mounted anywhere near the viewer rear panel. The pump is electrically connected to the outlet on the rear panel. This will allow pump operation via the main power switch on the viewer control panel.

The vacuum hose is pushed over the serrated fitting at the back of the viewer. The viewer is now ready for operation.

For ease in loading and unloading film chips, a work surface should be placed near the viewer for storing film and working with the film chip holders.

B. Loading the Viewer

Two film chip holders are provided. The two sizes accommodated are 4 x 5 sheets and 70 x 100mm unperforated film sections. Film is loaded in these chip holders in the same manner as in standard cut film holders.

The film is inserted in the holder upside down and emulsion up, as shown in Figure 12. After the film is in the holder, check to see that the back edge is under the chip holder lip.

The film chip holders are inserted into the viewer through the small hinged door on the top of the housing. This door is opened by a slight pull on the knob which disengages the catch.

NOTE: The viewer must be loaded and unloaded in the 5X position.

With the 5X position as noted above, the chip holder is inserted in the viewer slide with film toward the front of the viewer. As the holder is inserted, a vacuum seal is made by the spring clips pushing the chip holder to the vacuum input side of the Y slide. As this is done a change in sound of the vacuum pump will be noted if it is running. The vacuum pump is activated by the main power switch. The vacuum withdraws the air from between the film and the glass plate to provide a flat film plane. With the film inserted and the door closed, viewing may begin.

C. Basic Operation

1. Operator Position

The operator should sit with his eyes about 12 inches in front of the front panel. Head movement is possible, both forward (toward the viewer) and backward. The fore and aft movement may be a few inches and still maintain sufficient exit pupil relationship for proper viewing. Side to side and up and down movement of plus or minus an inch is within the usable exit pupil array. More movement than this is possible with some intensity fall-off for the outboard eye.

2. Operational Procedure

First depress the main power switch (the vacuum pump and fans will start). Then depress the illumination power switch. Adjust the intensity by rotating the control knob to increase or decrease the target brightness. This control knob will allow complete control of the brightness level.

At 5X, a 2 x 2 inch square area is observed. The film is moved by the viewing window by the lower buttons appropriately

arranged. The film is moved behind this window while any of the four switches are depressed; release of the switch stops the movement. The scanning rate is one inch every three seconds.

Manual fine focus is provided by the two knobs under the viewing window. For each revolution of the 5X knob the lens will move 0.006 inches.

When an area has been selected for examination at 50X, this area should be positioned in the center of the format by the X-Y translation controls. Once this has been accomplished the 50X magnification button is momentarily depressed. This causes the yoke to move the film to the other optical path. The viewer requires about three secs. to change magnifications. During this time the exit pupil will be dim. After the translation has been accomplished the corresponding lamp will be switched from a dim standby condition to the brightness level set.

The brightness setting at the 5X position is transferred to the 50X optical train and lamp. Any change made to the 50X lamp will likewise be transferred back to the 5X lamp when the change is made.

The fine focus knob to the left controls the 50X lens with one revolution moving the lens 0.002 inches.

Because of the small viewing area at 50X (.2 x .2 inch) and the fixed translation rate, it is felt that the most desirable method of operation is to select and position an area at 5X, the switch to 50X for analysis. When the next area is to be analyzed, return to the 5X position and translate the film in X-Y to the next area.

When this new area has been centered, switch back to 50X for analysis and so on. Small translations seem reasonable to make at 50X, but for large changes in X and Y it is worthwhile to wait the few seconds for the magnification change and return to 5X where a much larger area is available for viewing.

3. Safety Features

There are six limit switches on the translation mechanism. If an operator runs the X and Y movements too far the drive motors will be shut off before any mechanical interference occurs. The opposite X or Y control should be operated to return the film chip to the optical path.

Another safety feature is provided in the lamp cooling system. If for any reason a fan stops and the lamp housing heats up, the lamp will be shut off. This is performed by a thermostat mounted on the housing which senses the temperature and is adjusted to shut off the fan when a 15-20^{o} temperature rise occurs.

NOTE: If a lamp goes out during an operation, verify that the fan is still running before changing the bulb.

III. SERVICE INSTRUCTIONS

A. Lamp Replacement

The black louvered panel on the top of the machine is removed to gain access to the lamps. This panel is removed by a light pull on each of the four knobs.

After the panel is set aside the housing top must be removed. Four quarter turn wing head fasteners are released on the housing cover with the burned out lamp. With this cover removed the lamp may be pulled straight up for removal.

CAUTION: Wait until bulb cools before removal.
Pull straight up - do not twist.

Two 7/16 diameter metal pins protrude from the bottom of the 1500 watt DTS lamp and fit into spring loaded brass collars. These collars both support the bulb as well as supply it with electrical power. After the new bulb is inserted, replace the housing cover, and remember to latch this cover as the air from the fan could blow it off if it is not fastened. Then replace the louvered panel with the louvers deflecting the light and air toward the rear of the viewer.

B. Filter Replacement

By removal of the louver panel mentioned in the section above, the operator may reach the rear slot in each condenser housing. These slots contain the removable colored filters. A variety of colored filters may be inserted into this opening for testing and analysis. The filters must be 4" in diameter for the 5X condenser and 2-3/4" for the 50X condenser. Both filters should be 1/4 inch thick.

C. Inspection, Adjustment

The interior of the viewer is accessible after removal of the outer housing. The housing is best removed by two people after the 14 screws which hold it down are removed. With the housing removed all portions of the machine, except the drive package for the X translation, are easily accessible. The X translation drive is mounted under the condenser support floor. If adjustment of the distance traveled between magnification is required, the backplate must be removed. With the back plate removed the two microswitches S5 and S6 (Figure 9) may be adjusted.

Slight image displacements at 5X may be made by adjusting the screw on the side shown in Figure 7. With the mirror in the forward position the stop screw is adjusted until the mirror is aligned. Before attempting this adjustment, verify that the yoke moves the correct amount (8.865 inches) between the magnifications. This is accomplished by the microswitch mentioned above.

D. Optical Component Cleaning

It is recommended that any of the optic assemblies in the system be returned to the manufacturer in the event that internal optic surfaces require cleaning. The assembly procedures require special tools to avoid any damage to the precision optic surfaces.

The external optic surfaces of the assemblies may be cleaned, if necessary, by following the procedures recommended below. However, these recommended procedures will not guarantee that the lens surfaces will not be damaged.

1. Uncoated Glass Surfaces - Uncoated glass surfaces are found on the end of both condenser assemblies nearest the film plane, and on the filter assemblies inserted into both condenser assemblies.

Loose Particles and Dust - Loose particles and dust may be removed by gently brushing the surface with a soft camel's hair brush. This brush should be free from dust and oil (including oil from the hand).

Films - A film, such as many accumulate on a surface exposed to tobacco smoke or oil fumes STATINTL may be removed by first soaking the surface with MIR-O-Lens [redacted] STATINTL or acetone. Then gently wipe the surface dry with clean lens tissue or clean cotton balls. Any lint remaining then may be brushed from the surface with a camel hair brush.

2. Magnesium Fluoride Coated Glass - Magnesium fluoride coated surfaces are on all surfaces of the field less assembly, all surfaces of both objective lens, and all surfaces of both field flatteners.

Loose Particles and Dust - same as uncoated glass.

Films - same as uncoated glass.

3. Mirror Surfaces - Aluminized and Silicon Monoxide Overcoated - Aluminized and silicon monoxide overcoated mirror surfaces are found on the 2-path deflecting mirrors used on each side of the 5X objective lens.

Loose Particles and Dust - same as uncoated glass.

Films - same as uncoated glass.

4. Multilayer Coating (dicroic filters) - Multilayer coatings are used on the concave mirror surfaces behind both light sources, on the condenser surfaces nearest the lamps, and on the diagonal reflectors within the condenser assemblies.

WARNING - These coatings are very soft and quite easily damaged. The use of EXTREME care WILL NOT insure that the surface will not be damaged.

Loose Particles and Dust - same as uncoated glass.

Films - It is extremely difficult to clean a film deposit from a multilayer coated optical surface. First, it is quite deceiving as to whether or not a film is actually on the surface as some multi-layer coatings have a grayish, or cloudy, appearance under certain viewing conditions. Second, these coatings are quite soft and hence, easily damaged. Even under the best of conditions, using trained optical personnel, about 1 surface in 10 will be scratched during cleaning.

If it is absolutely necessary to clean a film from a multilayer coated surface, first soak the STATINTL surface with MIR-O-Lens [redacted] STATINTL or acetone. Then gently wipe the surface dry with clean lens tissue or clean cotton balls. Remove any lint remaining with a clean camel hair brush.

E. Electrical Circuits

Refer to the Electrical Schematic (Figure 13) for all call outs discussed in this section.

1. General

The POWER Switch on the front panel controls the Direct Image Viewer. The indicator lamps on this switch illuminate when AC power has been applied to the console. When the POWER switch is depressed, relay K1 is energized and provides power to the drive circuits and to the blowers B1 and B2, which are used to cool the projector lamps. Relay K1 routes 115V, 60 cycle power to the connector J2 which is provided for operation of external equipment. A total of 750 watts may be connected to this outlet. Fuse F1 provides protection for the Direct Image Viewer and any equipment connected to J2. After the POWER Switch has been depressed, the panel controls may be used to position the film chip frame assembly for loading.

2. Illumination

Illumination of the viewing area is provided by means of projector lamps DS9 and DS10. Depressing the LAMP Switch S2 energizes relays K2 and K7. Relay K2 applies power to the projector lamps DS9 and DS10. Initially, a low voltage is applied to both lamps to allow them to warm up. Approximately a second later relay K7 energizes and allows either relay K3 or K4 to become energized depending on which magnification selection switch has been depressed. Voltage from the illumination control circuit is applied to the lamp used with the magnification selected. Low voltage is applied to the projection lamps prior to the application of the higher viewing voltage to reduce the current surge which would tend to shorten the life of these lamps. Once the lamps are turned on, power is maintained on both lamps to keep their filaments warm and allow switching from one lamp to the other as magnifications are changed. Keeping the filaments warm also increases the life of these lamps. The light output of the lamp in use is controlled by the light intensity control R1 - R2 on the control panel. These rheostats

adjust the firing time of a pair of silicon controlled rectifiers CR1 and CR4 to vary the voltage applied to the projector lamp.

3. X-Y Translation

Since the entire slide chip in the viewing frame cannot be viewed at once, controls are provided on the front panel to move the slide chips both in the horizontal (X) and vertical (Y) directions. The slide chip may be moved horizontally to the right by depressing the RIGHT switch S13 on the control panel. Depressing switch S13 applies power to motor B5 and clutch L1, causing the slide chip being viewed to move to the right. Depressing the LEFT switch S12 also powers motor B5 and clutch L1 but reverses the direction of motor B5 and moves the slide chip to the left. These switches are of the momentary type and must be held depressed to move the slide chip. Similarly, the UP switch S14 drives motor B6 and moves the slide chip up while the DOWN switch S15 reverses motor B6 and moves the slide chip down. To prevent driving the Y-slide assembly against the stops either in the vertical or horizontal direction safety switches are provided. Limit switches S8 and S9 are connected in series with S14 and S15, respectively, to open these circuits and prevent damage to the Y-slide assembly and drive. Limit switches S10, S11, S19 and S20 are connected in series with the horizontal movement switches S12 and S13, respectively, to limit travel of the yoke assembly. Thus, if any of the X-Y coordinate switches are depressed sufficiently long to drive either the Y-slide or yoke assembly to the limits of its travel, it will actuate a limit switch and stop. It may then be returned towards center by depressing the opposite panel switch.

4. Magnification Translation

Magnification change is accomplished by depressing the 5X or 50X magnification switches. If it is desired to use the 50X magnification, the 50X magnification switch S3 is momentarily depressed. Switch S3 energizes relays K8 and K5. Relay K8 latches on its own contacts and provides power to motor B3 which drives the yoke assembly from the 5X position to the 50X position. The traversing mechanism is mechanically coupled to a counter gear which has cams to actuate switches S5 and S6. Since relay K9 gets its latching voltage through the contacts of switch S5, when this switch is actuated by the mechanical counter gear cam, it is opened and relay K6 is energized, stopping motor B3 and the yoke assembly. Relay K6 remains energized as long as the yoke assembly is in the 50X position. During this time, relay K5 is also latched on its own contacts and through switch S7 applies power to the mirror motor B4. Motor B4 moves the mirror in or out of the lens system as required. The mirror motor rotates a cam wheel which, when it has completed half of a revolution, opens switch S7, de-energizing relay K5 and stopping motor B4. Similarly, to move to the 5X position, the 5X switch S4 is momentarily depressed. Depressing switch S3 energizes relays K9 and K5. Relay K9 supplies power to the traversing motor B3 and it runs until the counter gear cam actuates switch S6. Actuation of switch S6 de-energizes relay K9 and relay K6 which brakes motor B3 as it stops. The mirror motor B4 again drives the cam wheel. When the cam wheel has completed 180° of rotation, it now actuates switch S21 opening it, and de-energizing relay K5 which stops motor B4.

During the time a magnification change is occurring, the projection lamps are dimmed. Both relays K8 and K9 energize relay K10, which in turn de-energizes relay K7. Relay K7 de-energizes both relays K3 and K4, putting low voltage on the lamps. When the yoke assembly completes its travel, relays K8, K9 and K10 are de-energized allowing relay K7 and either relay

K3 or K4 to energize, depending on whether switch S5 or S6 is actuated. The lamp at the magnification selected then returns to full brilliance.

5. Lamp Thermostats

Thermostats S16 and S17 are installed on the lamp housings to prevent possible damage due to a lamp breaking from over-heating. If sufficient air does not flow past the lamps to maintain the housing temperatures below that of the preset thermostats, the thermostats will open, de-energizing the associated relay K3 or K4. Low voltage is then applied to the lamps until the condition is corrected.

OPTICAL PLAN

DIRECT IMAGE VIEWER

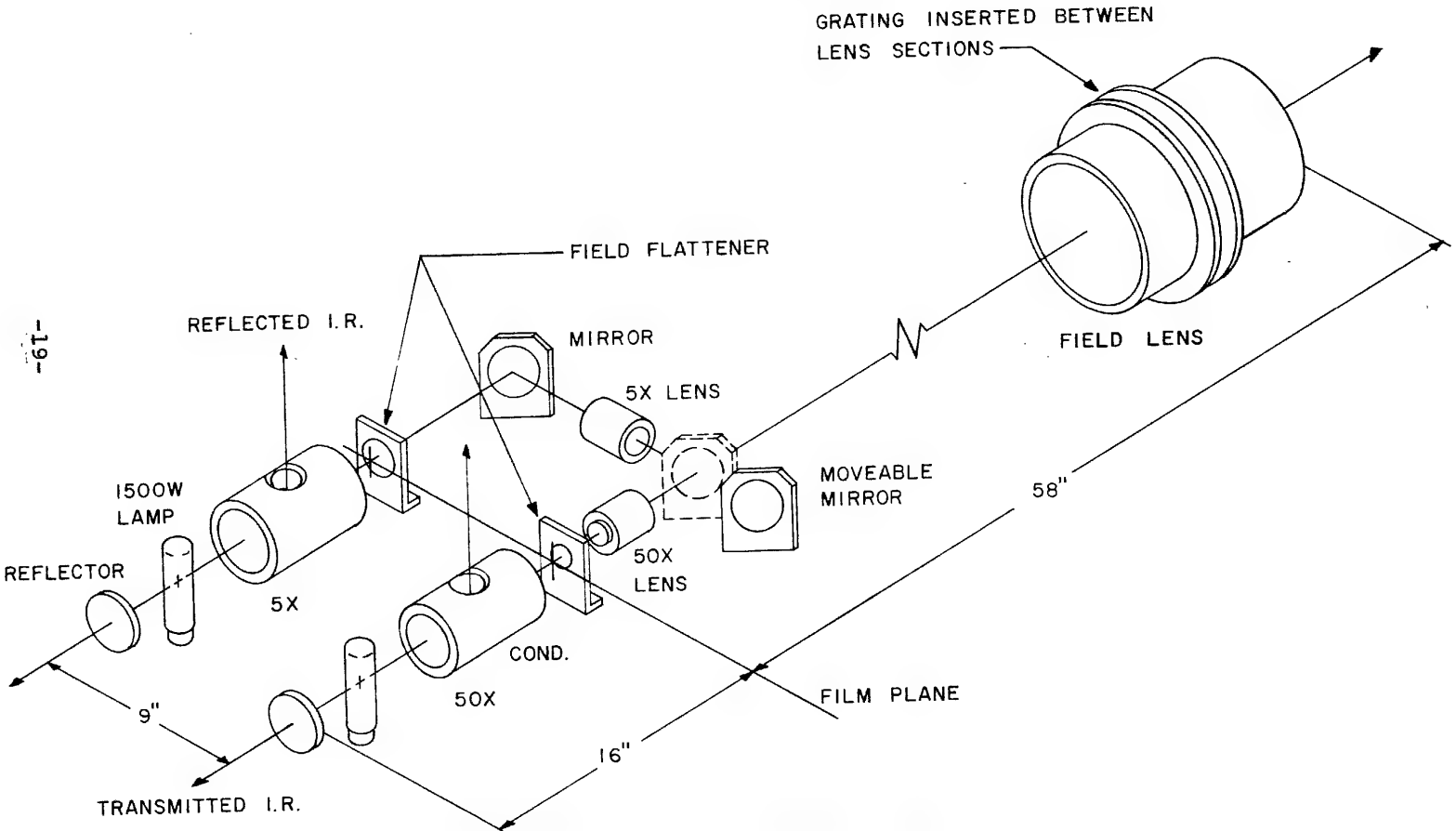
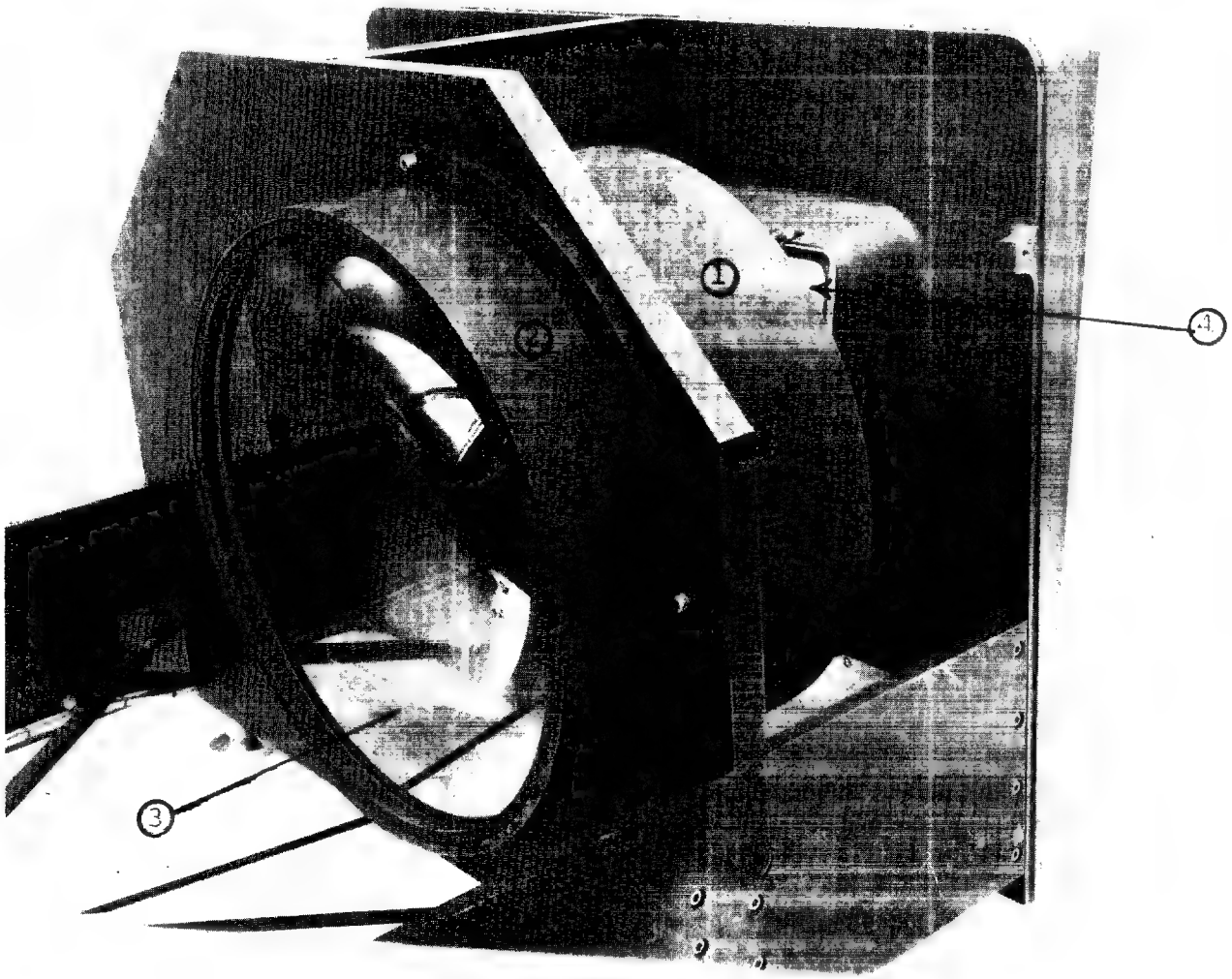


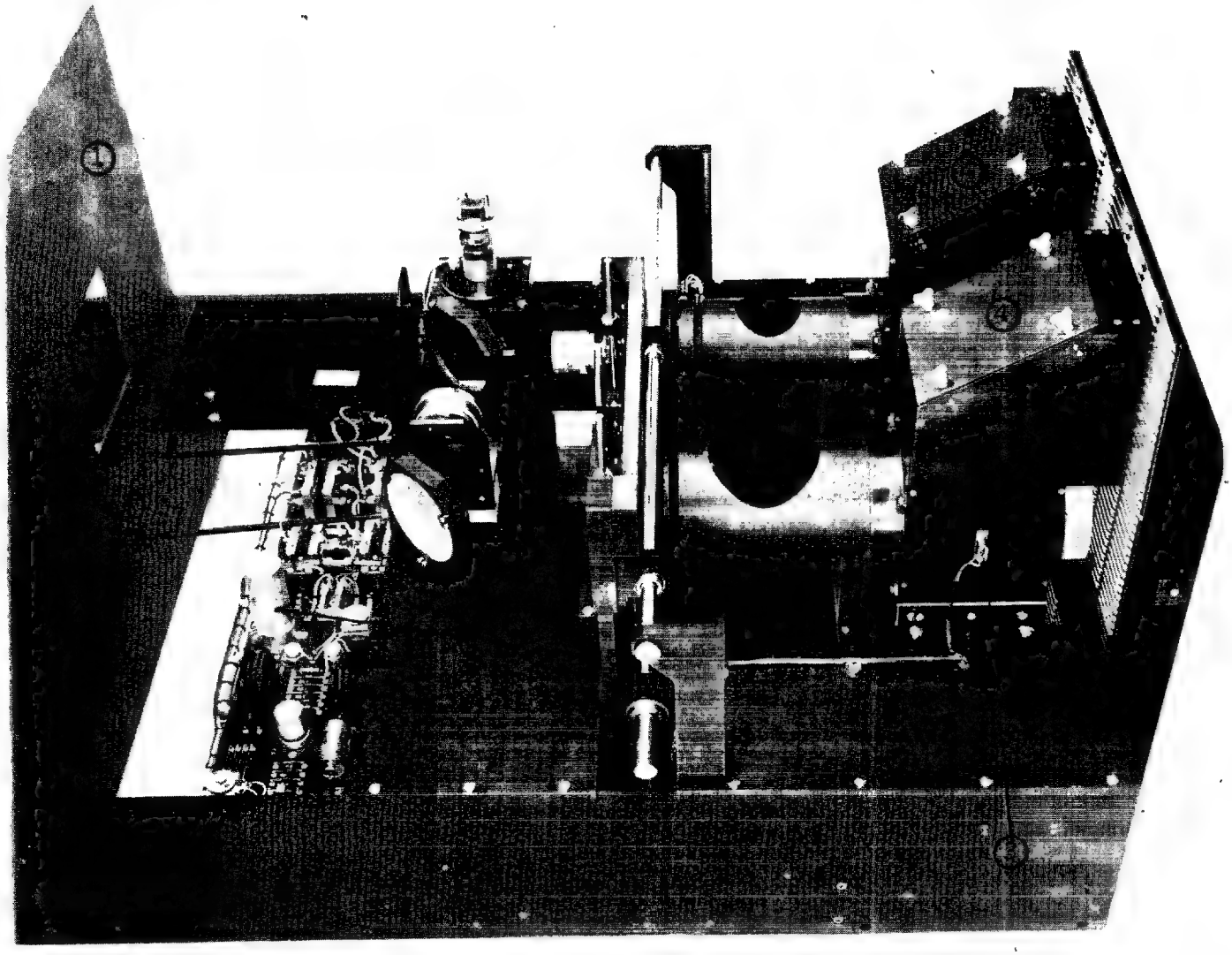
FIGURE 2



FIELD LENS ASSEMBLY

1. Field lens, front section, doublet
2. Field lens, rear section, single element
3. Diffraction grating and support
4. Viewing window

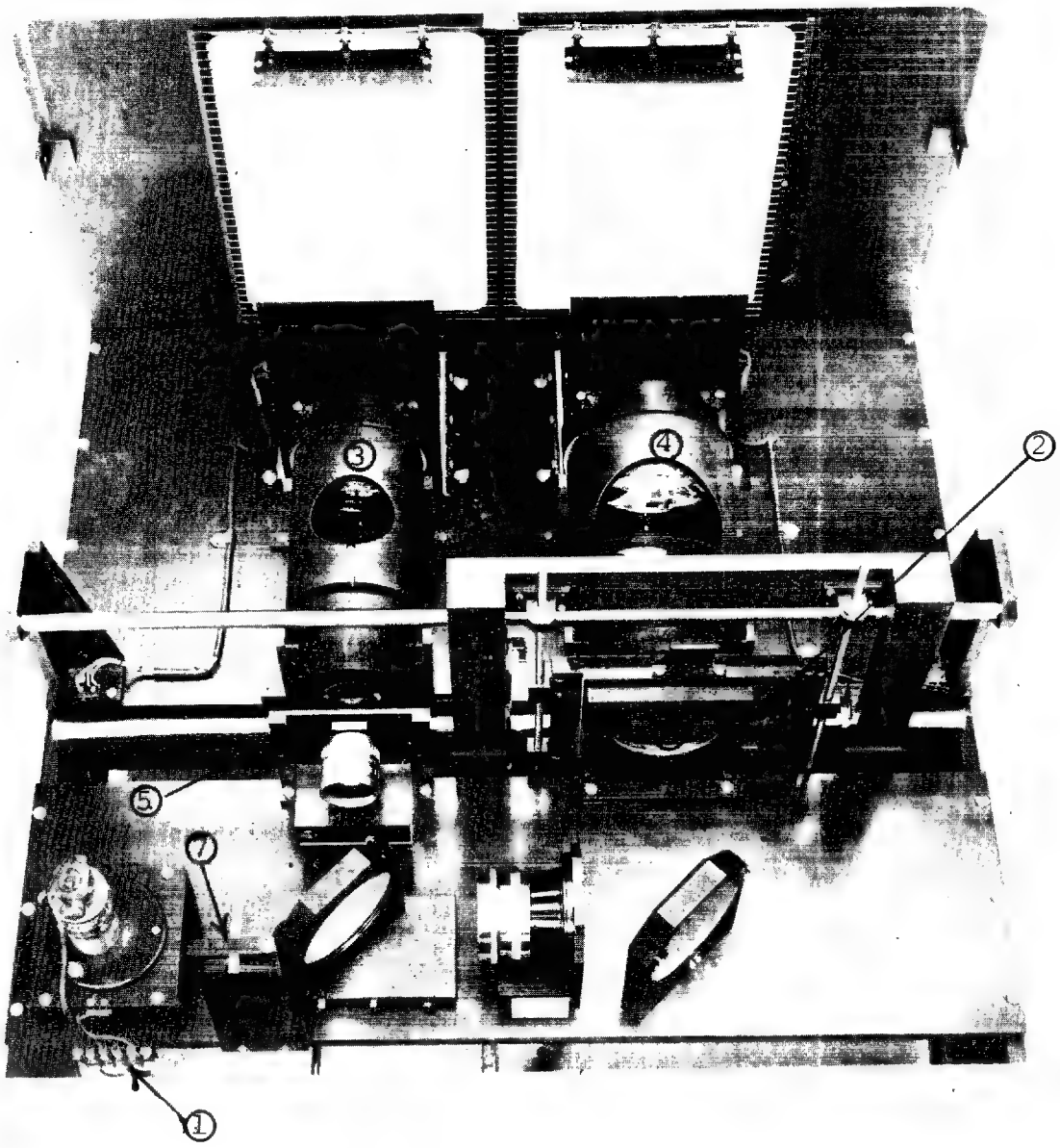
Figure 3.



REAR SECTION OF VIEWER

1. Light baffle
2. Electrical control chassis
3. Thermostat, lamp safety switch
4. Removable covers, for lamp replacement

Figure 4.



ILLUMINATION AND OBJECTIVE LENS ASSEMBLY
5X POSITION

① Terminal Board #8

② 4 x 5 Film Chip Holder

③ 50X Condensor

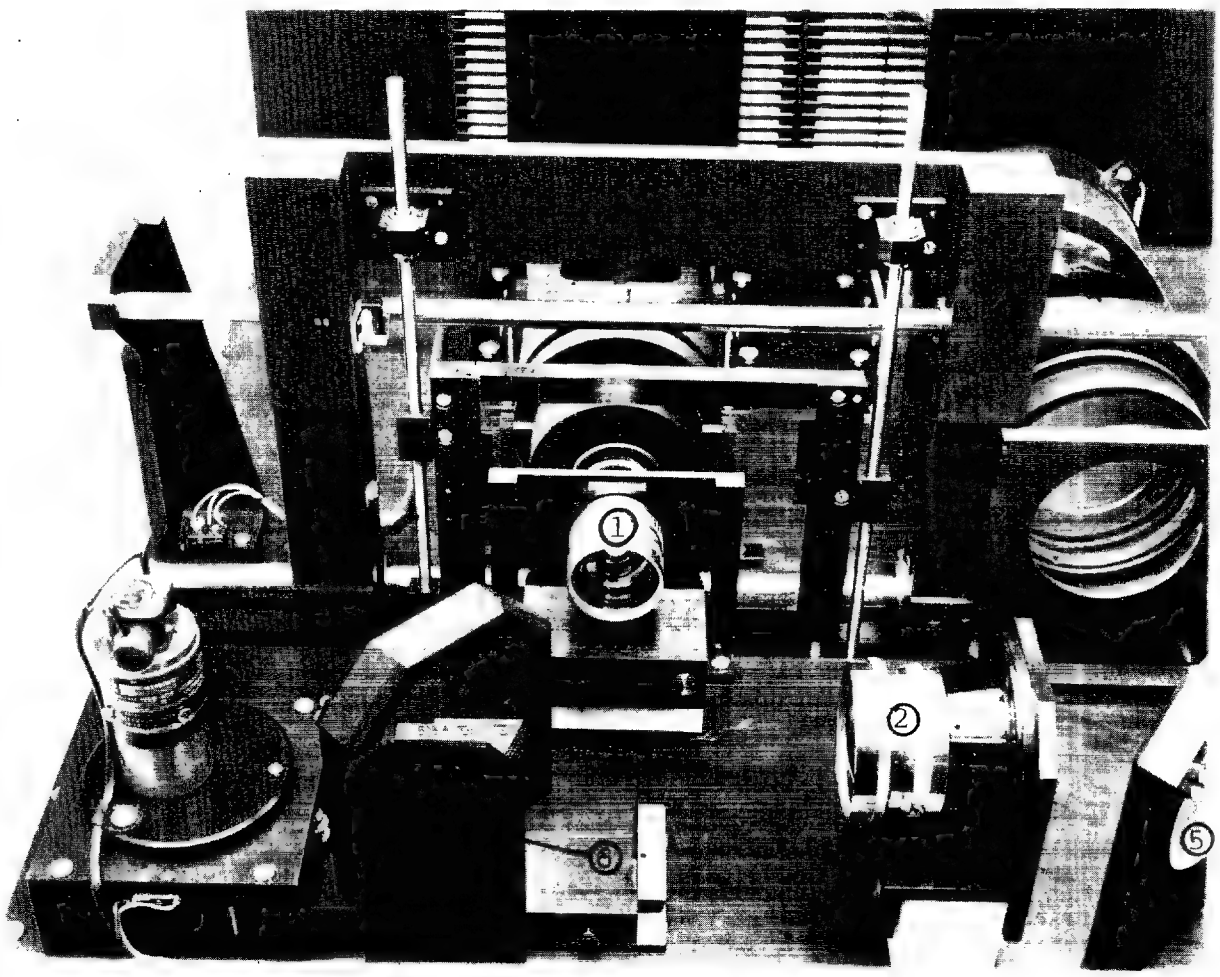
④ 5X Condensor

⑤ 50X Field Flattener

⑥ 5X Field Flattener

⑦ Mirror Slide Adjusting Screw (hidden)

Figure 5.



OBJECTIVE LENS ASSEMBLY
50X POSITION

① 50X Lens

② 5X Lens

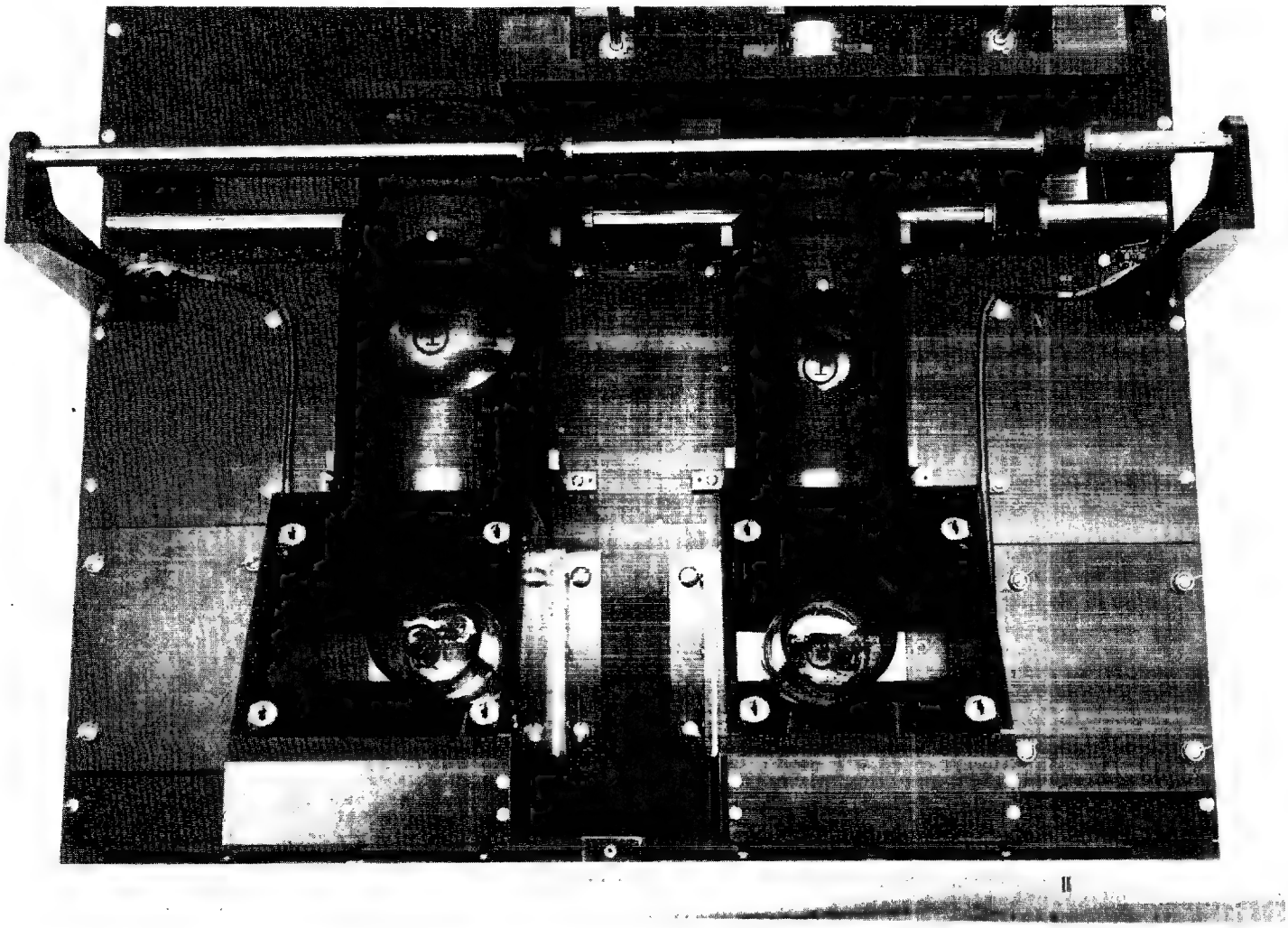
③ Movable Mirror for 5X Magnification

④ Mirror Motor Assembly

⑤ Stationary 5X Mirror

⑥ Light Baffle

Figure 6.



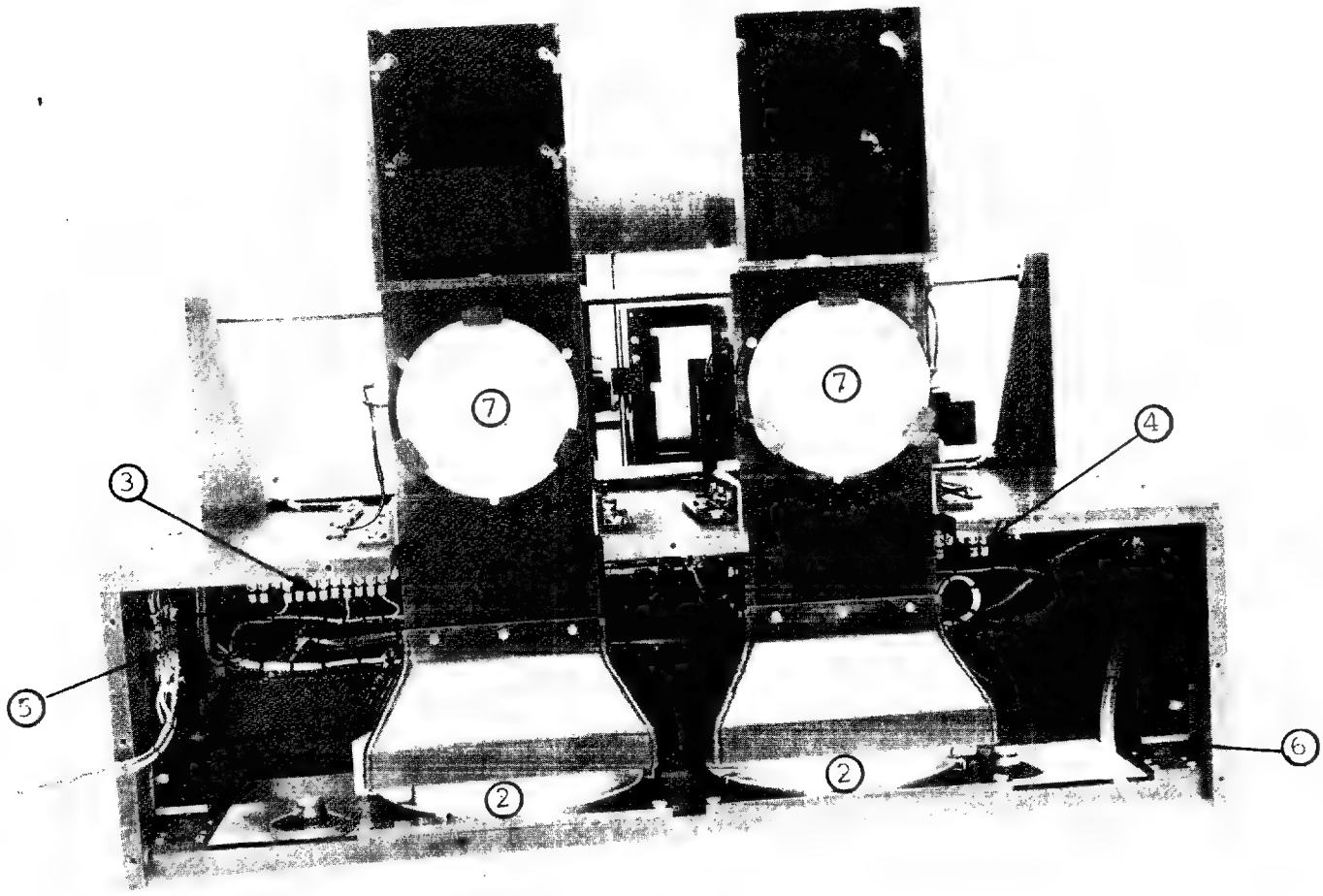
CONDENSER ILLUMINATION ASSEMBLY

① 45° heat reflecting mirrors

② 1500 Watt Projection lamps

③ Ball Bushings

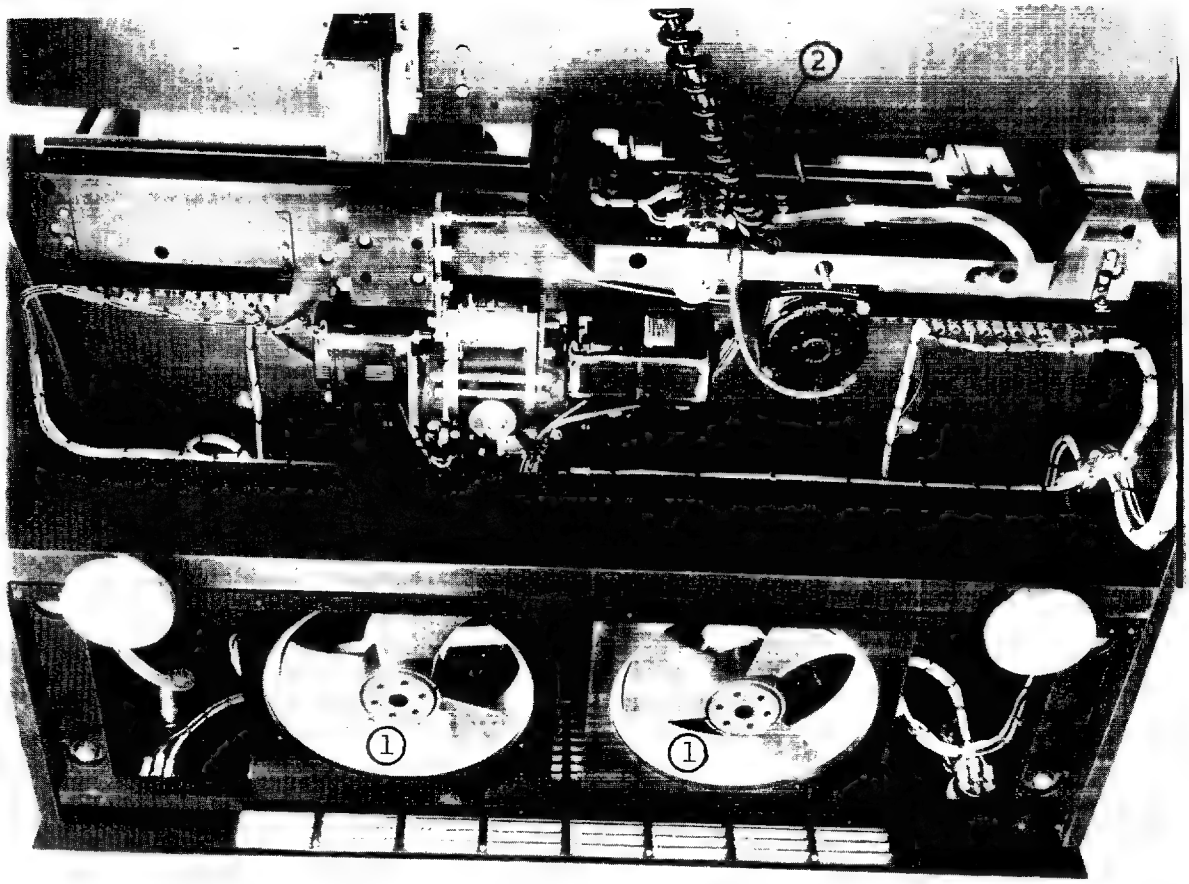
Figure 7.



VIEWER, REAR VIEW - LAMP HOUSINGS

1. Lamp Housings
2. Lamp Fans
3. Terminal Board #5
4. Terminal Board #4
5. Terminal Board #9
6. Vibration Isolation Mount - Fans
7. Infrared Transmitting Reflectors

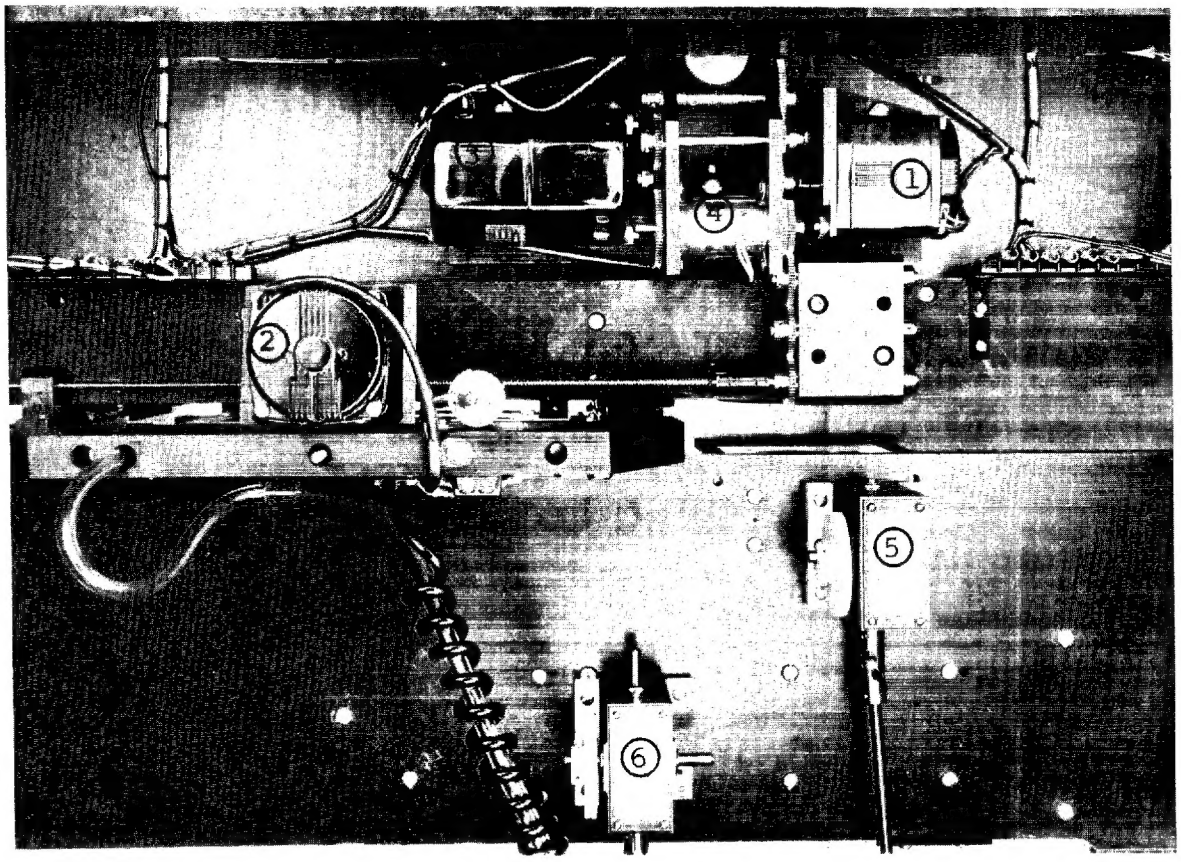
Figure 8.



BOTTOM VIEW, TRANSLATION AND LAMP FAN ASSEMBLIES

1. Lamp Fans
2. Terminal Board #3
3. Adjustable Microswitch S5
4. Adjustable Microswitch S6
5. Magnification Translation Cam Assembly

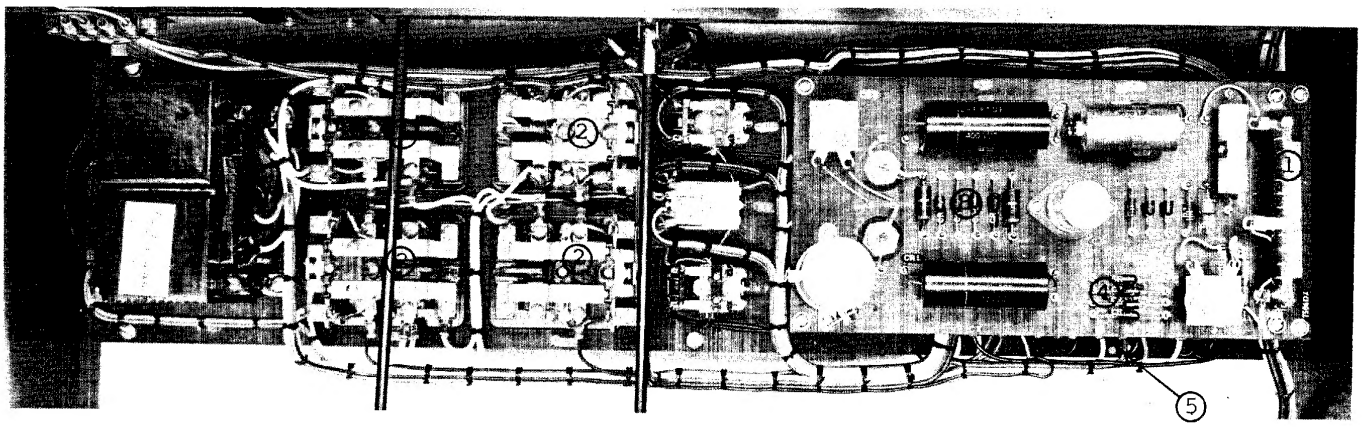
 Figure 9.



BOTTOM VIEW, TRANSLATION AND FOCUSING CAM ASSEMBLIES

1. X Movement Drive Motor
2. Y Movement Drive Motor
3. Magnification Translation Drive Motor
4. Duplex Clutch
5. 50X Worm Gear Box and Focus Cam
6. 5X Worm Gear Box and Focus Cam

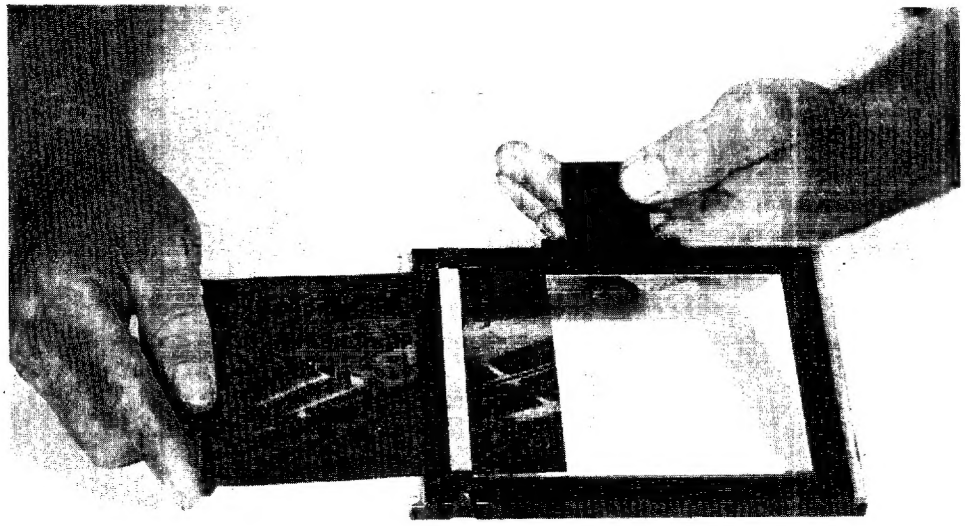
Figure 10.



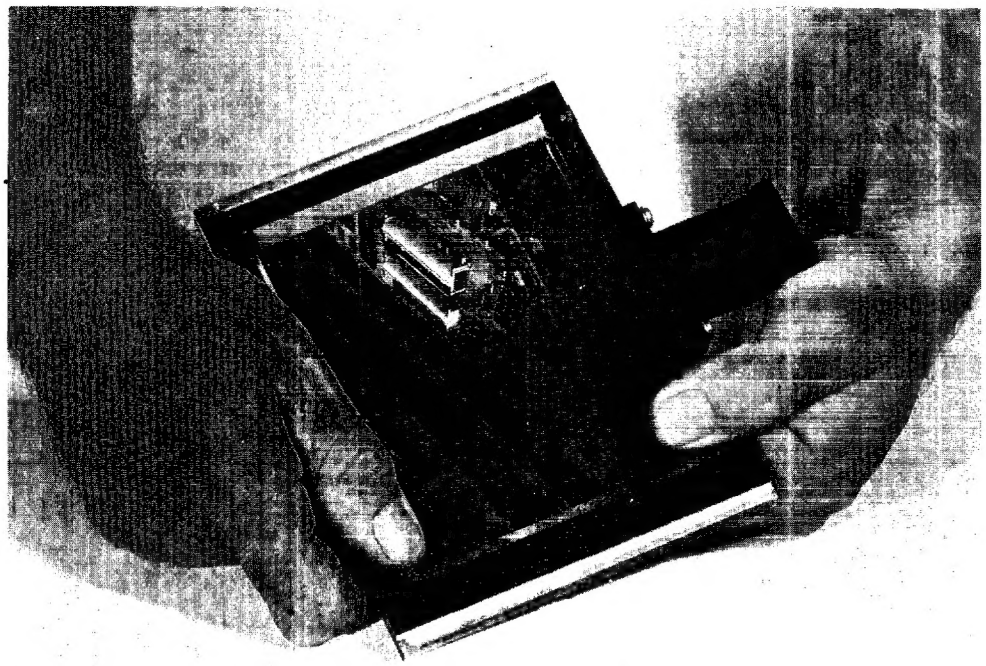
ELECTRICAL CONTROL CHASSIS

1. Speed Adjustment, Magnification Translation Motor
2. Illumination Control Relays
3. Brightness Control Circuit
4. Magnification Translation Motor Power Supply
5. Terminal Board #6

Figure 11.



Insert Film Under Teflon Coated Guide



Insert End of Film Under Lip

LOADING FILM HOLDER Figure 12.